

## **Calculating the number of settlements on the basis of the relationship of population density and density of settlements.**

In the cartography always been and still is the problem graphically display the reality surrounding us, which is the most detail, accurately and reliably transferred to the topographical plans and maps created on the basis of instrumental surveying and remote sensing data. With decreasing scale mapping and as a result - a sharp reduction in the charts increased density map objects, which leads to the need for selection. In this case the reality around us can not be described mathematically, because of the diversity of the objects, phenomena and their relationships, , and therefore can not justify mathematically accurate the selection of objects in the transition from scale to scale. Here there is appear the question of cartographic generalization. Generalization is one of the main problems of cartography. This process is complex. On cartographic generalization is depended by many factors, and therefore the process of generalization is very difficult to automate. That generalization need for to switch from larger scale maps to maps of smaller scale. This is switch from a single cartographic database to the map of any scale on any area of the world in the ideal case.

At the Department of Cartography of the Moscow State University of Geodesy was developed the automate system for the creation and transformation of small-scale cartographic basis. The system should provide automated creation of digital cartographic basis for any area of the world in the best map projection scale 1:2 500 000 and smaller. As part of this work was carried out studies on the establishment of the variation of the number of settlements and to develop the body of mathematics for the selection of settlements based on their density in the Russian Federation.

Settlements' selection results reached high similarity with existing cartographic products (maps and atlases, which were highly appreciated by experts).

Through the analysis of density settlements RF subjects to known small-scale maps (1:1 000 000, 1:2 500 000, 1:4 000 000 and 1:8 000 000) was determined density of settlements on the topographic map scale 1:1,000,000 and map of 1:8000000 scale. This was determined by ranking the subjects of the Russian Federation on the degree of density of settlements. It show agreement between of density of settlements and their ranking.

During the course of research, it became clear that transition to foreign territories requires different mathematics' body basis, since information on settlements' density all over the world, in different scales, is difficult to aggregate and maintain up to date.

The task was to make a transition, in terms of technology, from density of settlements to the population density. The population density data is easily available, in the actual status, on any area of the world.

In a review of more than 20 maps atlases scale of 1:2 000 000 to 1:8 000 000. Atlases were both Russian and German, English, Czech-made, published over the last 7 years. The country of Europe have been sorted by density for each of the scales. First, it appears that the same country depending on the scale occupies a different place on the density of settlements, and even in the atlases of the same publishing house (fig.1).

	1:2 000 000	1:3 000 000	1:4 000 000	1:5 000 000	1:6 000 000	1:7 000 000	1:8 000 000	Area	Density
Albania	29	31	29	31	31	29	32	33	22
Andorra	39	39	39	39	39	39	39	38	9
Austria	17	17	20	19	26	23	22	19	21
Belarus	13	13	13	11	11	13	11	12	35
Belgium	30	29	32	32	32	32	31	32	5
Bosnia and Herzegovina	27	23	23	25	29	28	30	25	25
Bulgaria	14	14	14	14	14	14	14	14	32
Croatia	21	18	17	16	24	24	25	24	30
Czech Republic	19	22	25	21	22	21	19	20	13
Denmark	22	24	19	15	19	19	18	28	14
Estonia	28	28	27	30	27	27	27	27	38
Finland	10	7	7	2	12	10	10	7	40
France	1	1	1	6	2	2	1	1	23
Germany	5	5	9	5	7	6	4	6	7
Greece	11	12	11	13	9	12	13	13	26
Hungary	18	16	22	20	15	15	17	16	18
Iceland	25	26	21	22	16	16	21	15	42
Ireland	20	21	16	18	20	18	15	21	33
Italy	6	6	4	4	4	4	5	9	12
Latvia	24	27	24	26	21	22	23	23	37
Liechtenstein	41	41	41	41	41	41	41	40	8
Lithuania	26	19	26	24	23	26	26	22	34
Luxembourg	37	37	37	37	37	37	37	37	10
Macedonia	35	33	34	34	34	34	34	34	27
Malta	38	38	38	38	38	38	38	39	2
Moldova	33	34	33	33	33	33	33	31	19
Monaco	40	40	40	40	40	40	40	42	1
Montenegro	36	35	35	36	36	36	36	36	36
Netherlands	23	25	28	28	25	25	24	29	4
Norway	8	8	8	12	10	9	9	5	41
Poland	9	11	12	8	6	8	8	8	15
Portugal	15	20	18	17	18	17	16	17	16
Romania	12	10	10	10	13	11	12	11	29
San Marino	42	42	42	42	42	42	42	41	3
Serbia	16	15	15	23	17	20	20	18	28
Slovakia	31	30	31	29	30	31	29	26	17
Slovenia	34	36	36	35	35	35	35	35	20
Spain	2	4	2	3	3	3	2	3	24
Sweden	3	3	6	9	8	7	6	4	39
Switzerland	32	32	30	27	28	30	28	30	11
Ukraine	4	2	3	1	1	1	7	2	31
United Kingdom	7	9	5	7	5	5	3	10	6

Figure.1. Table ranking countries on density of settlements, density of population and area.

Therefore, to properly make the schedule change in the number of settlements depending on the density as a starting point, we used data on the number of settlements in the area for each of the countries.

Secondly have been identified deviations in density in a number of countries with access to the sea. Apparently because the country is surrounded by the sea and it is more convenient to arrange signature of settlements there is a temptation to selection more settlements than need.

Third, comparing indicators of density and density found the relationship between the density of settlements and the density of population.

Fourth, identified areas with different types of placement of settlements, on that basis was adjusted our mathematic apparatus . Figure 4 shows a graph relationship between the density of settlements and the density of population., where  $K'$ ,  $K''$  and  $K'''$  - the correction coefficient for the different regions of Europe.

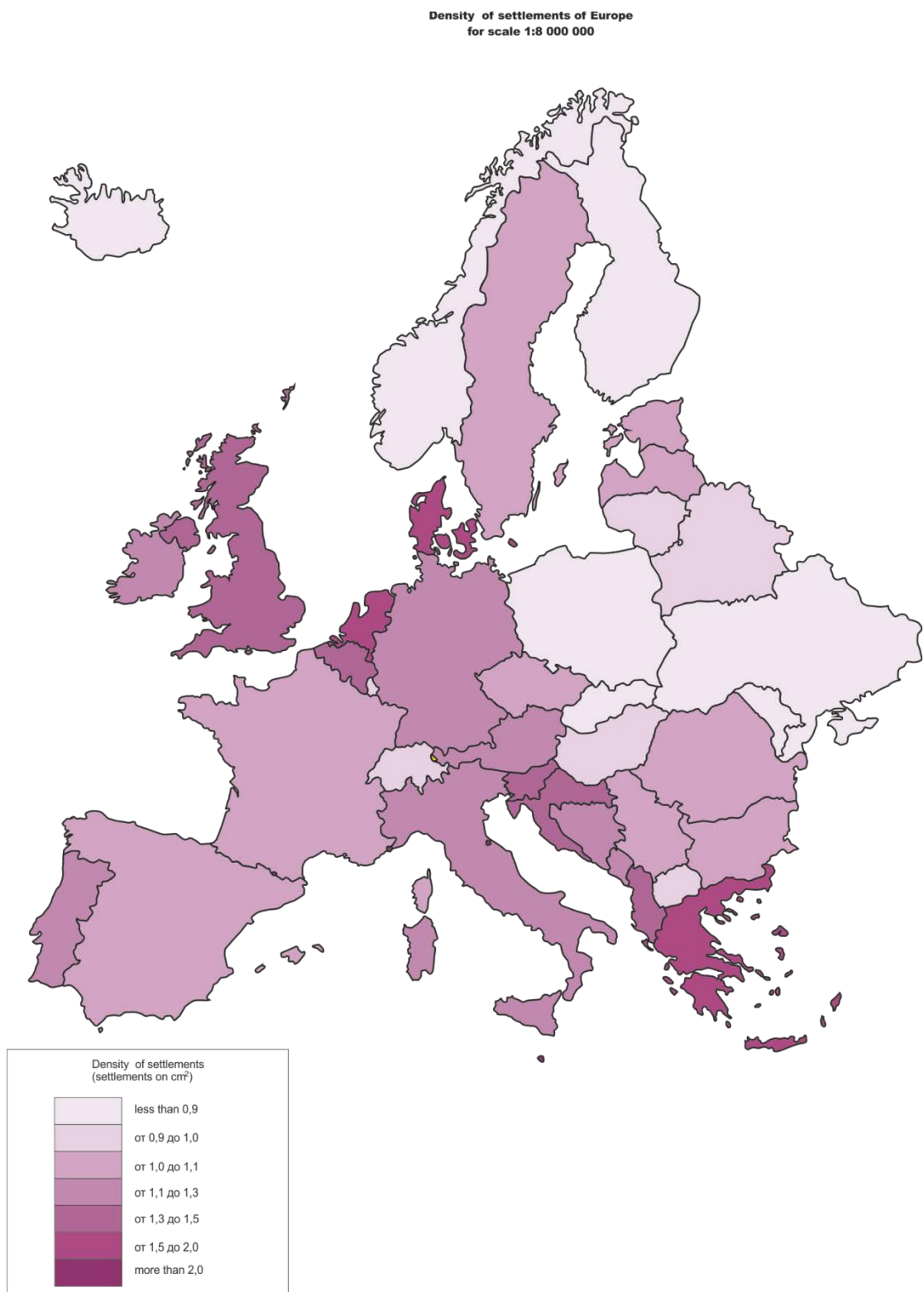


Figure 2. Density of settlements for the scale 1:2 000 000.

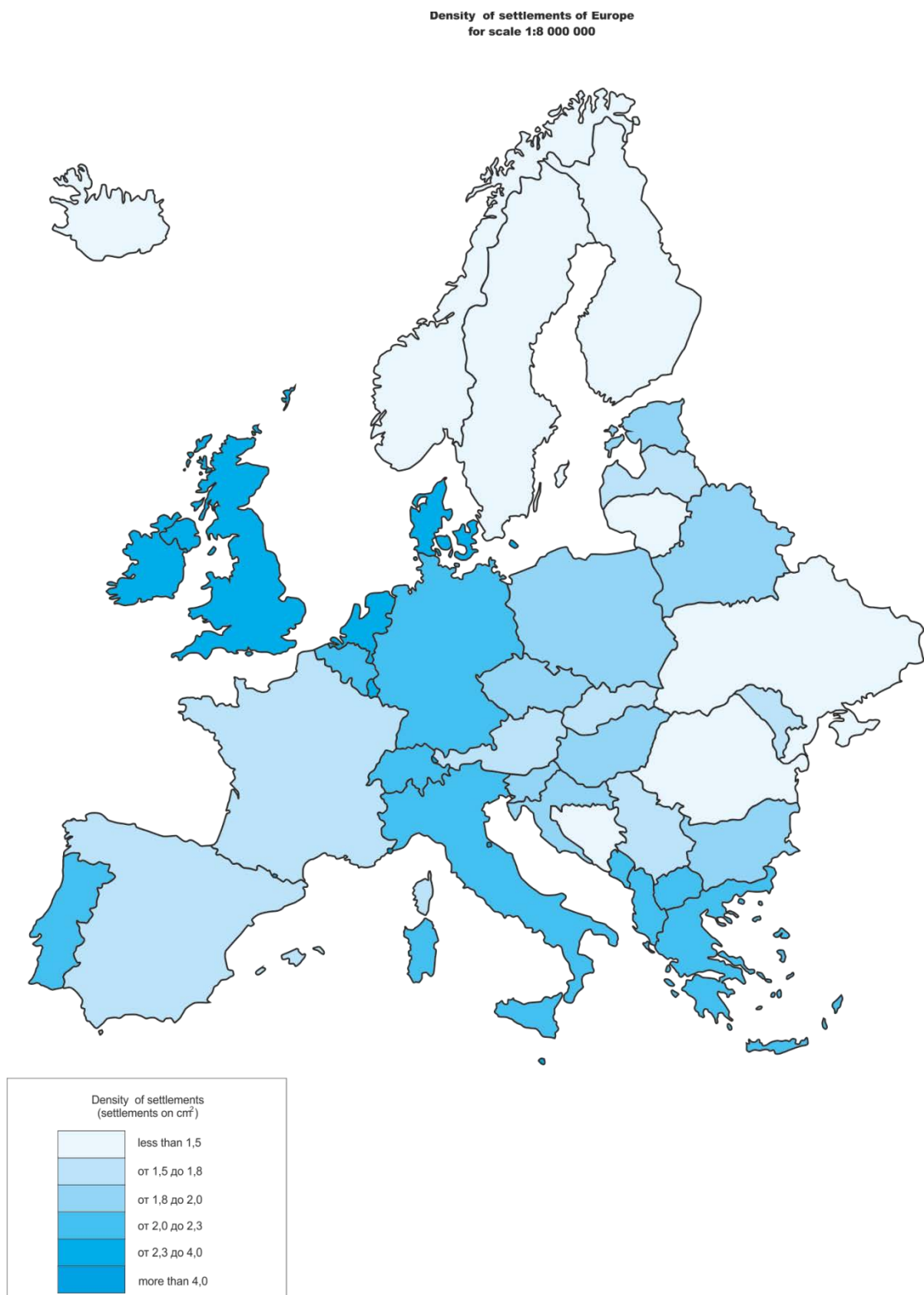
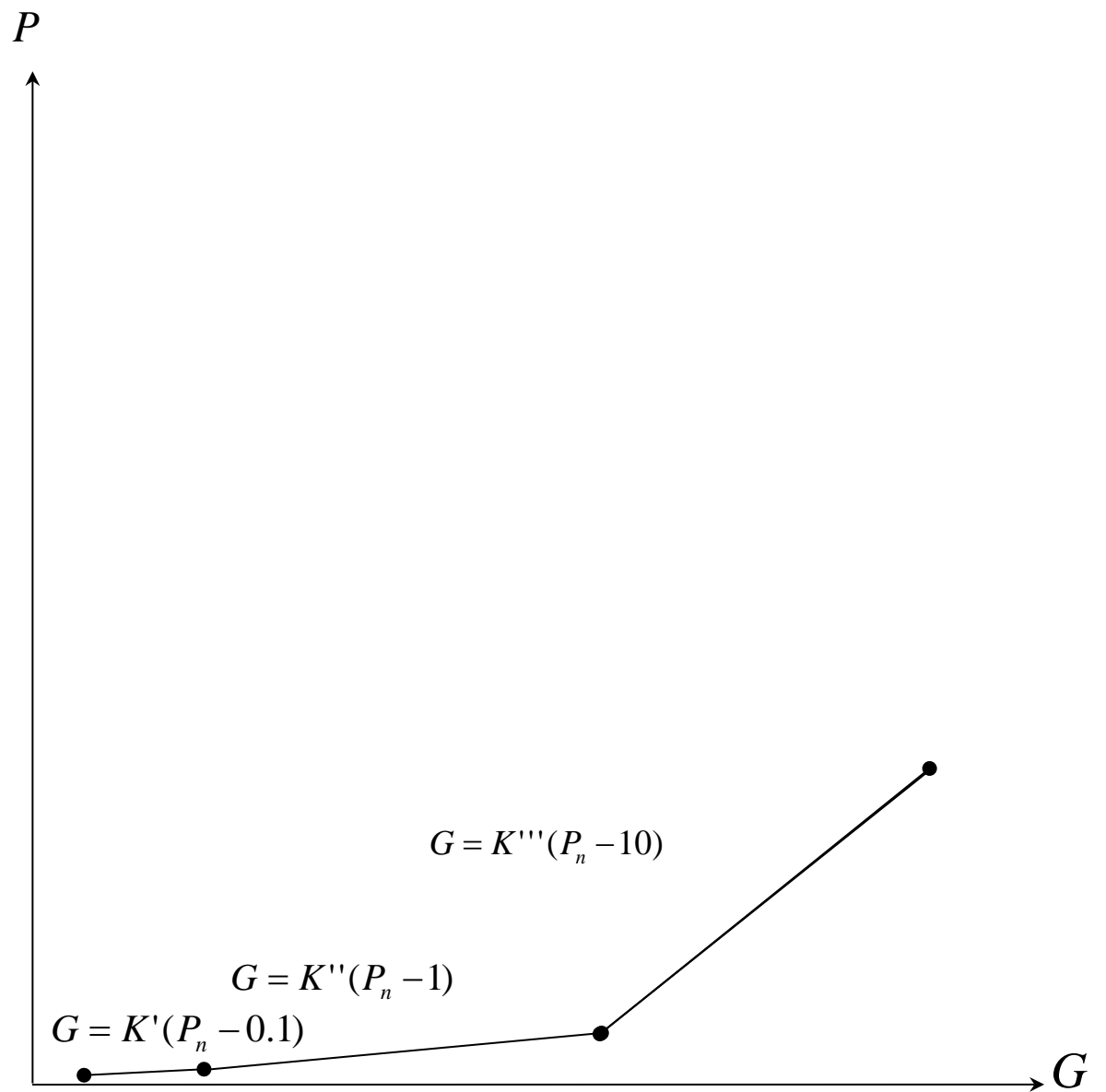


Figure 3. Density of settlements for the scale 1:8 000 000.

Figure 4. Relationship between the density of settlements and the density of population



On the basis of this relationship the mathematics' body was developed, which can calculate the number of settlements on the territory of a given set of scale. Analysis of these results shows very good agreement between theory and experimental data.

During the course of work, a thorough study on peculiarities of settlements' placement and distribution of European population was conducted.

Further research will concentrate on the study of the relationship between settlements' density and road density, which will allow us to make geographical demarcation of the territory on the basis of its development, since these two parameters are the key, when we are talking about the development of the territory